A New Species of *Pseudostellaria* (Caryophyllaceae) from Korea

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ABSTRACT. *Pseudostellaria longipedicellata* S. Lee, K. Heo & S. C. Kim is newly described from the Taebaek Mountain Range across three eastern provinces (i.e., Gangwon, Chungcheongbuk, and Gyeongsangbuk) of the Korean Peninsula. *Pseudostellaria longipedicellata* is similar to *P. palibiniana* (Takeda) Ohwi by having an open flower, glabrous pedicel, and slender taproots, but differs by its shorter, decumbent, and slender stems, oblanceolate leaves distally changing to elliptic or narrowly ovate, and the fertile pedicel that elongates to the ground when bearing fruit. A dichotomous key to the Korean species of *Pseudostellaria* Pax is provided in this paper. Also discussed are the major differences of *P. longipedicellata* from its congeners, and the new species' possible pollination and dispersal mechanisms.

Key words: Ant pollination, Caryophyllaceae, cleistogamy, IUCN Red List, *Pseudostellaria*.

Pseudostellaria Pax (Caryophyllaceae) refers to the genus of false chickweeds or stitchworts with about 21 species found in temperate regions. The greatest species diversity is in Asia, with 17 species; a single species is known from Europe; and three species are described from North America (Ohwi, 1937; Mabberley, 2008). The number of *Pseudostellaria* species distributed on the Korean Peninsula varies from five species (Chung, 1957), six species (Lee, 1979), or nine species (Ohwi, 1937; Lee, 1996; Lee, 1998) according to the checklists or floras. Choi (1993, 1999) extensively reviewed the genus in Korea and recognized the reported taxa as six species, with two new hybrids. The genus is distinguished by its fusiform tubers, with both chasmogamous and cleistogamous flowers (Flora of China online, 2008).

During fieldwork, a putative new species from Mt. Taebaek Provincial Park was originally encountered and reported (Lee, 1997, as nom. nud.). This new taxon appeared similar to *Pseudostellaria palibiniana* (Takeda) Ohwi, sharing the subverticillate, distalmost leaves, fasciculate tubers, glabrous pedicels, and solitary and terminal flowers (Ohwi, 1937; Choi, 1993; Lee, 1997); however, the new species, *P. longipedicellata* S. Lee, K. Heo & S. C. Kim, validly described herein differs from *P. palibiniana* in many quantitative vegetative and floral characters (Table 1), and it significantly differs from its congeners in its stem and leaf shape and pedicel length. The stems of *P. palibiniana* (13.5 ± 3.3 cm) are erect and robust, generally taller than those of *P. longipedicellata* (9.2 ± 2.1 cm), which are basally decumbent and slender. The four distalmost leaves of *P. palibiniana* are narrowly ovate to elliptic, but are noted as ovate after anthesis; these leaves in *P. longipedicellata* are oblanceolate or lanceolate, but are post-anthesally observed as elliptic or narrowly ovate. The fruiting pedicel of *P. palibiniana* does elongate, but not as extensively as was observed for *P. longipedicellata*, where the pedicel elongates until reaching the ground (Figs. 1, 2).

Pseudostellaria longipedicellata S. Lee, K. Heo & S. C. Kim, sp. nov. *Pseudostellaria pendula* S. Lee, nom. nud. A Key to the Vascular Plants of Korea, 170–171. 1997. TYPE: Korea. Gangwon: Mt. Taebaek, under larch forest near S entrance of Mt. Taebaek Provincial Park, 1 June 1996, *S. T. Lee s.n.* (holotype, SKK; isotypes, MO, SKK). Figures 1–3.

Species nova *Pseudostellariae palibinianae* (Takeda) Ohwi affinis, sed ab ea foliis apicalibus primum oblanceolatis vel lanceolatis post anthesin ellipticis vel anguste ovatis atque pedicello in fructu deorsum extenso humum attingente distinguitur.

Perennial herbs; rhizomatous with 3 to 20 aerial stems; taproots 1 to 4, with slender and fusiform tubers, 5–13.5 × 0.14–0.25 cm; stems basally decumbent, slender, 6–14 cm, with 1 or 2 vertical rows of trichomes. Proximal leaves oblanceolate or spatulate, pubescent along proximal margin, 1.2–3 × 0.3–0.6 cm; middle leaves similar but 1.8–4.2 × 0.3–0.7 cm; distalmost leaves oblanceolate or lanceolate, subverticillate; with 4 ± whorled, the 2 larger ones 2–3.9 × 0.4–1.3 cm, the other 2 markedly smaller, nearly sessile, pubescent along proximal margin; whorled leaves change to elliptic or narrowly ovate. Flowers solitary and terminal; pedicels 3.1–4.8 cm, glabrous or rarely basally pubescent, post-anthesally elongating 3.8–6.9 cm until reaching the ground. Sepals 6 to 9, lanceolate, glabrous, margin membra-

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Table 1. Morphological comparison of *Pseudostellaria palibiniana* (Takeda) Ohwi and *P. longipedicellata* S. Lee, K. Heo & S. C. Kim. The values obtained in this study were measured from 16 specimens (minimum – means ± standard deviation – maximum).

Characters	*P. palibiniana*	*P. longipedicellata*
Petal number	5–6.3 ± 0.63–7*	6–6.7 ± 0.78–9
Petal length (mm)	4.5–5.9 ± 0.71–7.2*	2.9–4.5 ± 0.68–5.4
Petal width (mm)	1–1.5 ± 0.26–2*	1–1.5 ± 0.3–2
Sepal length (mm)	3.5–5.5 ± 1.16–7.8*	3.6–4.3 ± 0.49–5.1
Sepal width (mm)	0.8–1.2 ± 0.24–1.8*	0.7–1.3 ± 0.27–1.8
Style number	2–3.6 ± 0.76–5*	3–3.42 ± 0.51–4
Stem length (cm)	7.3–13.5 ± 3.3–19.5	6–9.2 ± 2.05–14
Pedicel length (cm)	1.8–2.4 ± 0.3–2.8	3.1–4.1 ± 0.52–4.8
Fruit pedicel length (cm)	1.8–2.6 ± 0.5–3.7	3.8–5.5 ± 0.88–6.9
Distalmost subverticillate whole leaf length (cm)	1.9–3.7 ± 0.7–5	2–2.8 ± 0.59–3.9
Distalmost subverticillate whole leaf width (cm)	0.6–1.1 ± 0.41–2	0.4–0.7 ± 0.3–1.3
Distalmost subverticillate whole leaf length (L) and width (W) ratio (L/W)	2–3.7 ± 1.47–7.1	2.7–4.4 ± 1.14–7.1
Mature distalmost subverticillate whole leaf length (cm)	2.7–5.5 ± 1.54–9.9	3.1–4.7 ± 1.21–8.6
Mature distalmost subverticillate whole leaf width (cm)	1.1–2.5 ± 0.72–4.6	0.6–2 ± 0.81–4.6
Mature distalmost subverticillate whole leaf length (L) and width (W) ratio (L/W)	1.7–2.2 ± 0.32–3.1	1.8–2.6 ± 0.69–4.9

* Values marked with asterisks were adapted from Choi (1999). Vouchers for *P. palibiniana* include *S. Kim s.n.* (SKK-19960427001), *H. Kim s.n.* (SKK-19960428001), *S. T. Lee s.n.* (SKK-20070503001), *D. Jo s.n.* (SKK-19950603001), *K. Heo & J. Goh HKI050013* (SKK), *S. T. Lee & K. Heo HKI050015* (SKK), *S. T. Lee & K. Heo S.Lee050010* (SKK), *K. Heo et al. HKI050030* (SKK), *K. Heo et al. HKI20070427001* (SKK), *K. Choi 234* (KNU), *K. Choi 26* (KNU), *J. H. Park 4026* (KNU), *J. H. Park 5536* (KNU), *Y. Wong et al. s.n.* (KNU-00000143), *S. W. Park et al. 80* (KNU), *K. Choi et al. 8* (KNU), *S. A. Lee 2* (KNU), *S. Y. Choi s.n.* (KNU-00012050), *Y. J. Jo s.n.* (KNU-00012046), *J. H. Park s.n.* (KNU-00012057), *J. H. Park et al. 3570* (KNU), and *J. H. Park 3672* (KNU).

nous, 3.6–5.1 × 0.7–1.8 mm; petals 6 to 9, obovate, apex acute, emarginate, obtuse, or round, white, 2.9–5.4 × 1–2 mm; stamens 12, filaments 3.1–4.4 mm, anthers 0.5–0.6 mm; ovaries syncarpous, with 3 to 4 carpels, ovate, 1.3–2.8 × 1.3–2.6 mm, style distinct, 2–3.7 mm, stigma filiform to clavate. Fruit as capsule, reddish brown, septicidally dehiscent; seeds (4 to)9(to 15), reniform, 1.8–2.6 × 1.7–2.2 mm, papillose, the papillae distributed evenly, roundly conical, their anticlinal cell walls branching radially and irregularly, tightly interwoven with other cell walls, the spinules of papilla slender, 0.02–0.03 mm.

Phenology. *Pseudostellaria longipedicellata* was observed to flower in April with fruiting from May to June.

Distribution. *Pseudostellaria longipedicellata* is endemic to Mts. Taebaek, Daedeok, Deokhang, and Myeon in Gangwon Province, Korea. It was also collected from Mts. Worak and Joryeong in Chungcheongbuk Province and Mt. Naeyeon in Gyeongsangbuk Province and Mt. Biseul in Daegu Metropolitan City.

IUCN Red List category. *Pseudostellaria longipedicellata* is native to three eastern provinces, i.e., Gangwon, Chungcheongbuk, and Gyeongsangbuk, as well as Daegu Metropolitan City on the Korean Peninsula. Additional populations likely exist along the Taebaek Mountain Range, a north- to south-trending belt running along the eastern margin of the Korean Peninsula. The population size is small (usually less than 100 individuals per population) and several such small populations are sporadic in each locality (or mountain). Populations are typically found in mid to lower elevations of mountains, especially along the hiking trails or park entrances. Recently, some populations, including the type locality, have been threatened and have declined due to construction of some park structures, such as buildings and parking lots. It is urgent to take additional ecological and biological study for effective conservation measures. We recommend an IUCN Red List category of Endangered, with small or declining populations (EN, C2) (IUCN, 2001).

Ecology and phenology. *Pseudostellaria longipedicellata* is sympatric with *P. setulosa* Ohwi, occurring along roadsides, and may be found on somewhat dry leaf mold in larch forests (*Larix* Mill.) near the south entrance of Mt. Taebaek National Park. Its flowering time overlaps with that of *P. setulosa*, beginning in April. Only a few individuals (approximately up to 50 with varying distances from a few centimeters to 1–2 m) of *P. longipedicellata* were observed and these small populations were sporadic. In contrast, the sympatric species *P. setulosa* grew extensively and continuously from its rhizomes. Few individuals of the new species were encountered at locations other than the type locality. *Pseudostellaria*

longipedicellata was noted along roadsides on nearby Mt. Myeon in Gangwon; it was also seen at dry, sunny sites in rocky places in Mt. Worak National Park in Chungcheongbuk Province. Through examination of specimens in other herbaria, the distribution of the described species extended further south to Mt. Naeyeon as well as in Daegu Metropolitan City and Gyeongsangbuk Province.

Etymology. The specific epithet *longipedicellata* highlights the dramatic elongation of the fertile pedicels post-anthesally.

Common name. Tae-baek-gae-byeol-ggot (Korean). The vernacular name Taebaek was taken from the type locality, in Mt. Taebaek National Park.

Discussion. *Pseudostellaria longipedicellata* also appears to be closely related to *P. okamotoi* Ohwi, endemic to Mt. Jiri in Gyeongsangnam Province. However, *P. okamotoi* is easily distinguished from *P. longipedicellata* by having puberulent pedicels (Ohwi, 1937). Interestingly, both species share the intriguing elongation of the fruiting pedicels. Pedicels in *P. okamotoi* elongate (2.3–3.8 cm, sensu Choi, 1993) and bend downward (Choi, 1993), but not to the extent observed for *P. longipedicellata* (3.8–6.9 cm).

Pseudostellaria heterophylla (Miq.) Pax, which occurs widely in the entire Korean Peninsula, is also similar to the new species, sharing four ± whorled distalmost leaves and their shapes. Differences in *P. heterophylla* include more flowers at stem apices (one to eight vs. one in *P. longipedicellata*), only a single taproot (vs. one to four), and leaf blades that are basally ciliate/pubescent (vs. pubescent along the proximal margin in *P. longipedicellata*). Pedicels of *P. heterophylla* are shorter (5.8–28.5 mm) and lack the dramatic elongation seen in the new species (Choi, 1993).

The surface morphology of seeds is variable and different among the species of *Pseudostellaria* in Korea (Choi, 1999). The seed surfaces of *P. palibiniana*, *P. okamotoi*, and *P. heterophylla* show roundly conical papillae distributed evenly, with the anticlinal cell walls branching radially and irregularly and tightly interweaving with adjacent cells. Slender spinules are seen at the top of papillae. In contrast, the branches of anticlinal cell walls are few and rough in *P. heterophylla* (Choi, 1999: 25, fig. 5), many and delicate in *P. palibiniana* (Choi, 1999: 26, fig. 9), or intermediate in *P. okamotoi* (Choi, 1999: 26, fig. 7). In particular, *P. longipedicellata* and *P. palibiniana* are quite distinct in several features of surface morphology (cf. Fig. 3). Branching of anticlinal cell walls of *P. longipedicellata* appear short and wide, but are long and narrow in *P. palibiniana*; spinules of the former are short, but elongate in the latter; ultra-reticular calcium carbonate debris on the papilla of the former is scarce or absent, but evenly distributed in the latter. The seed surface morphology of *P. longipedicellata* is quite distinctive from that of *P. palibiniana*, and more closely resembles that of *P. okamotoi* (Choi, 1999: 26, fig. 7).

Cleistogamy is common within *Pseudostellaria* (Ohwi, 1937), and the cleistogamous capsules are borne at the axil of leaves typically at the proximal part of the stem. Based on the authors' observations, cleistogamous capsules appear to be rare in *P. longipedicellata*, in contrast to *P. palibiniana* and *P. heterophylla*. This may suggest that *P. longipedicellata* is a facultative autogamous species, with this observation supported by the fact that in this species, seed sets approach 100% (S. T. Lee, unpublished).

The color of fruits and pedicels is reddish brown. This color and the ground-level fruit might suggest that the fruits attract ants and that the seeds are dispersed by ants (Fig. 2D). Many wandering ants were observed under the clustered plants of *Pseudostellaria longipedicellata*, although ant dispersal of seeds was not directly observed. Among other taxa, ant-pollinated flowers bloom near the ground and/or exhibit similar reddish brown perianths (Proctor & Yeo, 1973; Beattie, 1985). This has been noted in *Asarum* L. (Aristolochiaceae; Smith et al., 1989), *Leavenworthia* Torr. (Brassicaceae; Wyatt, 1981), *Lepidium* L. (Brassicaceae; Gomes et al., 1986), *Balanophora* J. R. Forst. & G. Forst. (Balanophoraceae; Kawakita & Kato, 2002), *Microtis* R. Br. (Orchidaceae; Peakall & Beattie, 1991), as well as other Caryophyllaceae, including *Arenaria* L. and *Gypsophila* L. (Gomes et al., 1986). Ants may disperse small seeds of many annual herbs (Lach, 2003), including *Stellaria* L., which is affined to *Pseudostellaria* (Kjellsson, 1985). The clustered habit of plants of *P. longipedicellata* may be caused not only by short rhizomes but also by the ants that collect the seeds for food reserve (Beattie, 1985; Lach, 2003). We did observe moist capsules that were partially foraged by insects (Fig. 2F), although in none of them did the dried capsule dehisce naturally. We did not observe any insect taxa other than ants in association with the fruits. Further studies are required to confirm the pollination and seed dispersal mechanisms in *P. longipedicellata*.

Paratypes. (Asterisks indicate collections measured for Table 1). KOREA. **Chungcheongbuk:** Chungju, Seokmun-dong, 16 May 2006, **G. H. Nam NGH60317* (KH);

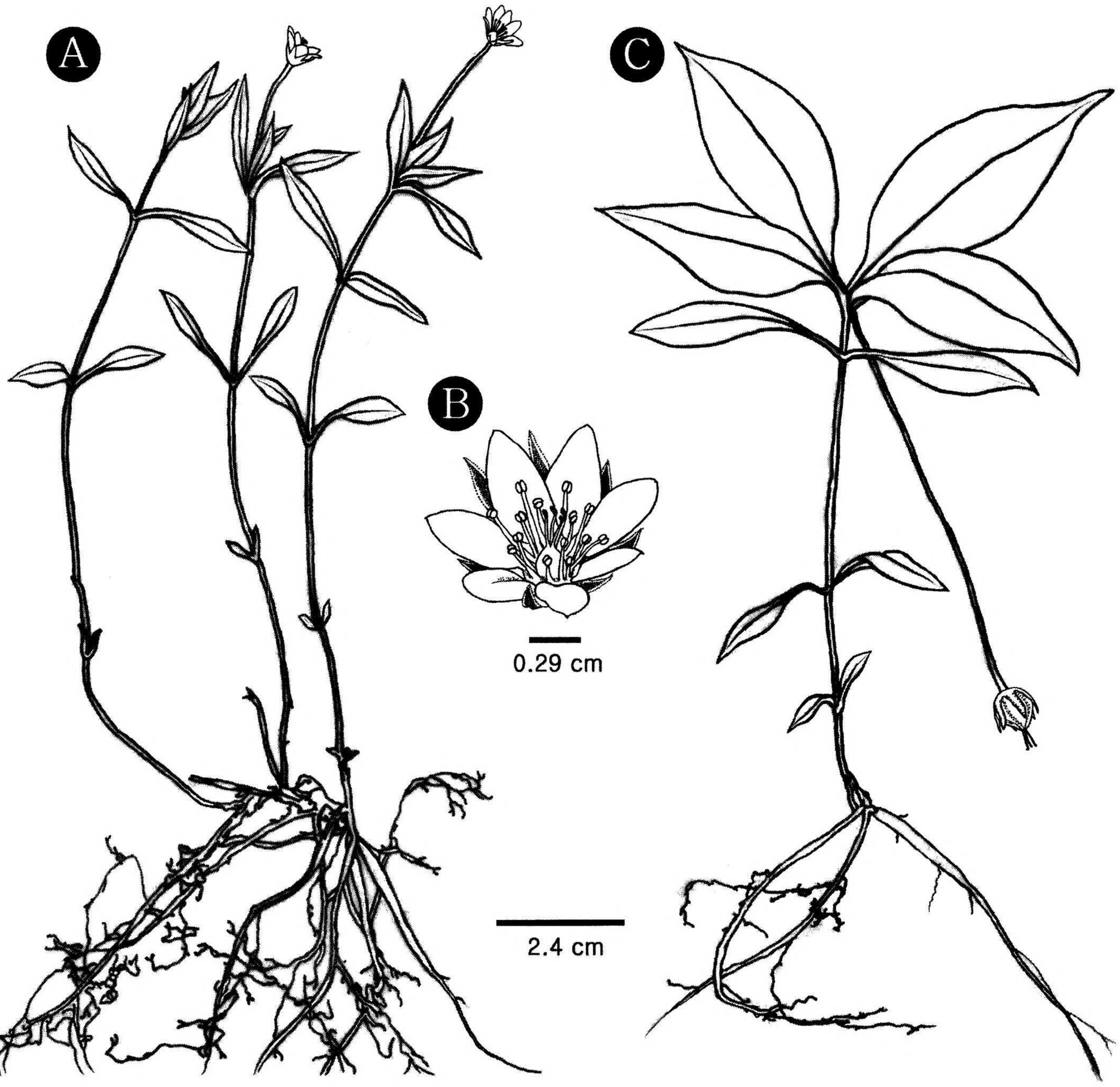

Figure 1. *Pseudostellaria longipedicellata* S. Lee, K. Heo & S. C. Kim. —A. Habit of flowering plant. —B. Flower. —C. Habit of fruiting plant, showing the post-anthesal elongation of the pedicel. A, B drawn from *Heo et al. HKI060010* (SKK); C drawn from *Heo HKI050010* (SKK).

Jecheon, Seongnaeri, 15 May 2006, **G. H. Nam & H. S. Choi NGH60170* (KH); Mt. Joryeong, 17 May 2006, **S. H. Park & H. S. Choi Park SH63491* (KH); Mt. Weorak, 4 May 2002, **S. T. Lee et al. 26376* (SKK), 4 May 2002, **S. T. Lee et al. 26377* (SKK), 4 May 2002, *S. H. Park SH21161* (KH), 4 May 2002, **S. H. Park SH21149* (KH), 4 May 2002, *S. H. Park SH21165* (KH), 4 May 2002, *S. H. Park SH21150* (KH), 4 May 2002, *S. H. Park SH21164* (KH). **Daegu Metropolitan City:** Mt. Biseul, 18 May 1997, **J. H. Park 4026* (KNU). **Gangwon:** Mt. Daedeok, 18 June 2005, **K. I. Heo & J. E. Go s.n.* (SKK); Mt. Deokhang, 23 May 2004, **J. S. Kim kjs050066* (KH); Mt. Myeon, 30 Apr. 2006, **K. I. Heo et al. HKI060010* (SKK); Mt. Taebaek, 1 June 1996, *S. T. Lee et al. s.n.* (SKK), 7 May 1999, **C. J. Lee s.n.* (SKK), 24 May 2002, **S. T. Lee et al. s.n.* (SKK), 2 May 2004, **K. I. Heo et al. s.n.* (SKK), 2 May 2004, *H. M. Hwang et al. s.n.* (SKK), 2 May 2004, *M. H. Im et al. s.n.* (SKK), 15 May 2005, *S. T. Lee et al. s.n.* (SKK), 15 May 2005, *M. H. Im et al. s.n.* (SKK), 15 May 2005, *N. I. Gong et al. s.n.* (SKK), 15 May 2005, *S. R. Lee et al. s.n.* (SKK), 15 May 2005, *Y. D. Kim et al. s.n.* (SKK), 15 May 2005, *T. E. Park et al. s.n.* (SKK), 4 June 2005, **K. I. Heo et al. HKI05510* (SKK). **Gyeongsangbuk:** Mt. Naeyeon, 13 Apr. 1992, **K. Choi 26* (KNU), **K. Choi 27* (KNU).

KEY TO *PSEUDOSTELLARIA* SPECIES IN KOREA MORPHOLOGICALLY SIMILAR TO *P. LONGIPEDICELLATA* (ADAPTED FROM CHOI [1993, 1999] AND LEE [1997])

1a. Distal leaves subverticillate; flowers terminal (*Pseudostellaria* subser. *Verticillate* Ohwi) 2
  2a. Taproots several, fascicled; pedicels glabrous; flowers solitary and terminal 3
    3a. Stems basally erect and robust, 7.3–19.5 cm; distal subwhorled leaves narrowly ovate or elliptic and becoming ovate; pedicel elongating 1.8–3.7 cm, but not to the ground ..... *P. palibiniana*

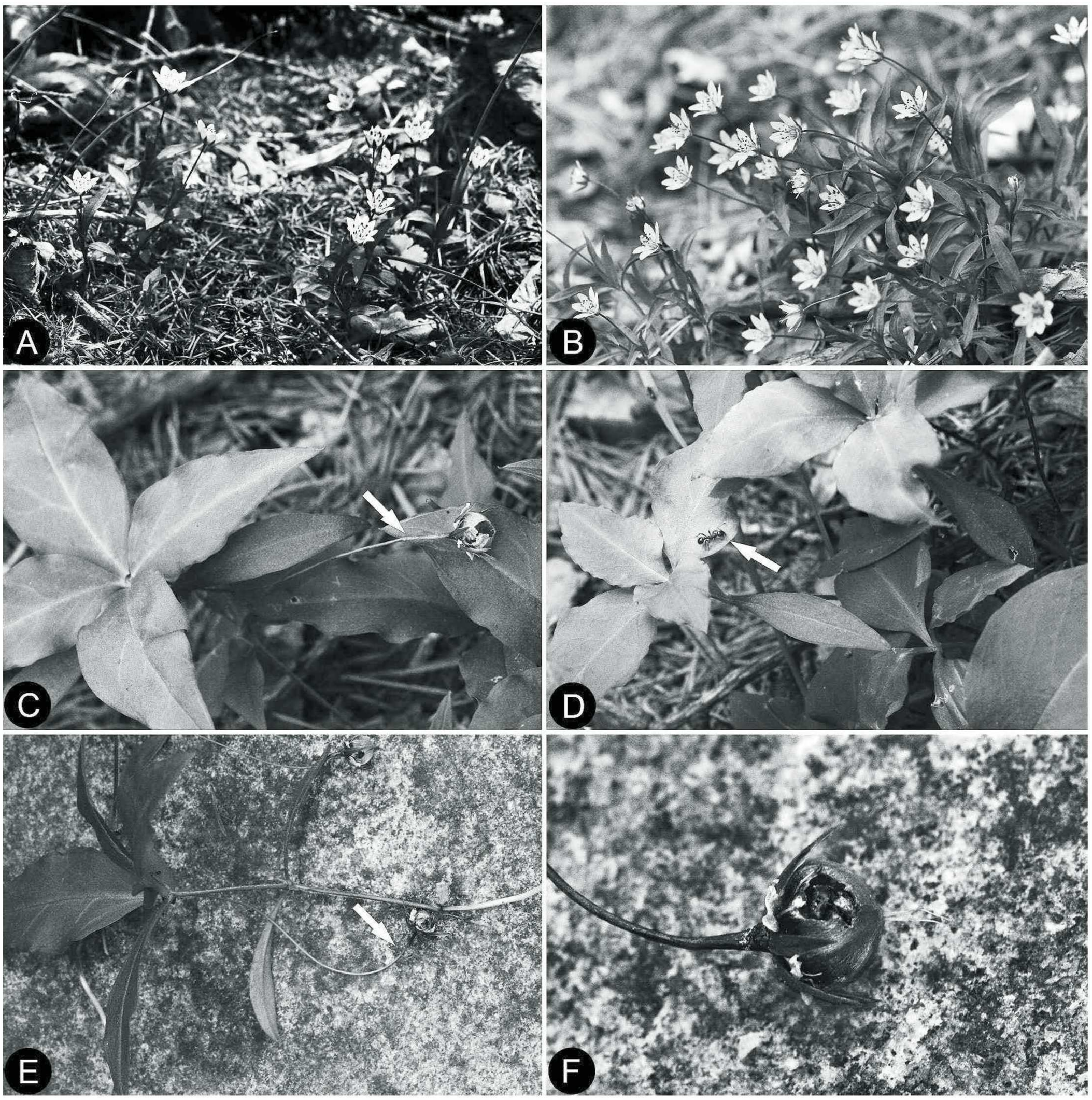

Figure 2. *Pseudostellaria longipedicellata* S. Lee, K. Heo & S. C. Kim during the anthesal period in 2007 at the type locality in Gangwon Province, Korea. —A. Flowering, which started by April 27. —B. Clustered plants in full bloom on April 30. —C. Elongated pedicels (indicated by one arrow) of early flowers on May 4. —D. Ant on leaf. —E. Post-anthesal pedicels complete in their elongation and dropping (at arrow) on June 4. —F. Close-up of a fruit foraged by insects on June 4. Photographs taken by K. I. Heo and Samjo Chung.

3b. Stems basally decumbent and slender, 6–14 cm; distal subwhorled leaves oblanceolate or lanceolate and becoming elliptic or narrowly ovate; pedicel extends down 3.8–6.9 cm until reaching the ground ..... *P. longipedicellata*

2b. Taproots 0 to 2; pedicels pubescent; flowers 1 to 5 per stem and terminal 4

4a. Pedicels vertically pubescent along one side; flowers solitary per stem; petals acute ..... *P. okamotoi*

4b. Pedicels entirely pubescent; flowers 1 to 5 per stem and terminal; petals emarginated 5

5a. Roots fusiform, not long-rhizomatous; leaves basally pubescent; flowers 1 to 8 per stem, petals 5 ..... *P. heterophylla*

5b. Roots fibrous, long-rhizomatous; leaves pubescent along the midrib and margin; flowers solitary per stem, petals 6 ..... *P. setulosa*

1b. Distal leaves opposite; flowers terminal or lateral (*Pseudostellaria* subser. *Distantes* Ohwi) 6

6a. Stems erect, not creeping; distal leaves linear to lanceolate ..... *P. sylvatica* (Maxim.) Pax

6b. Stems erect, creeping after anthesis; distal leaves obovate ..... *P. davidii* (Franch.) Pax

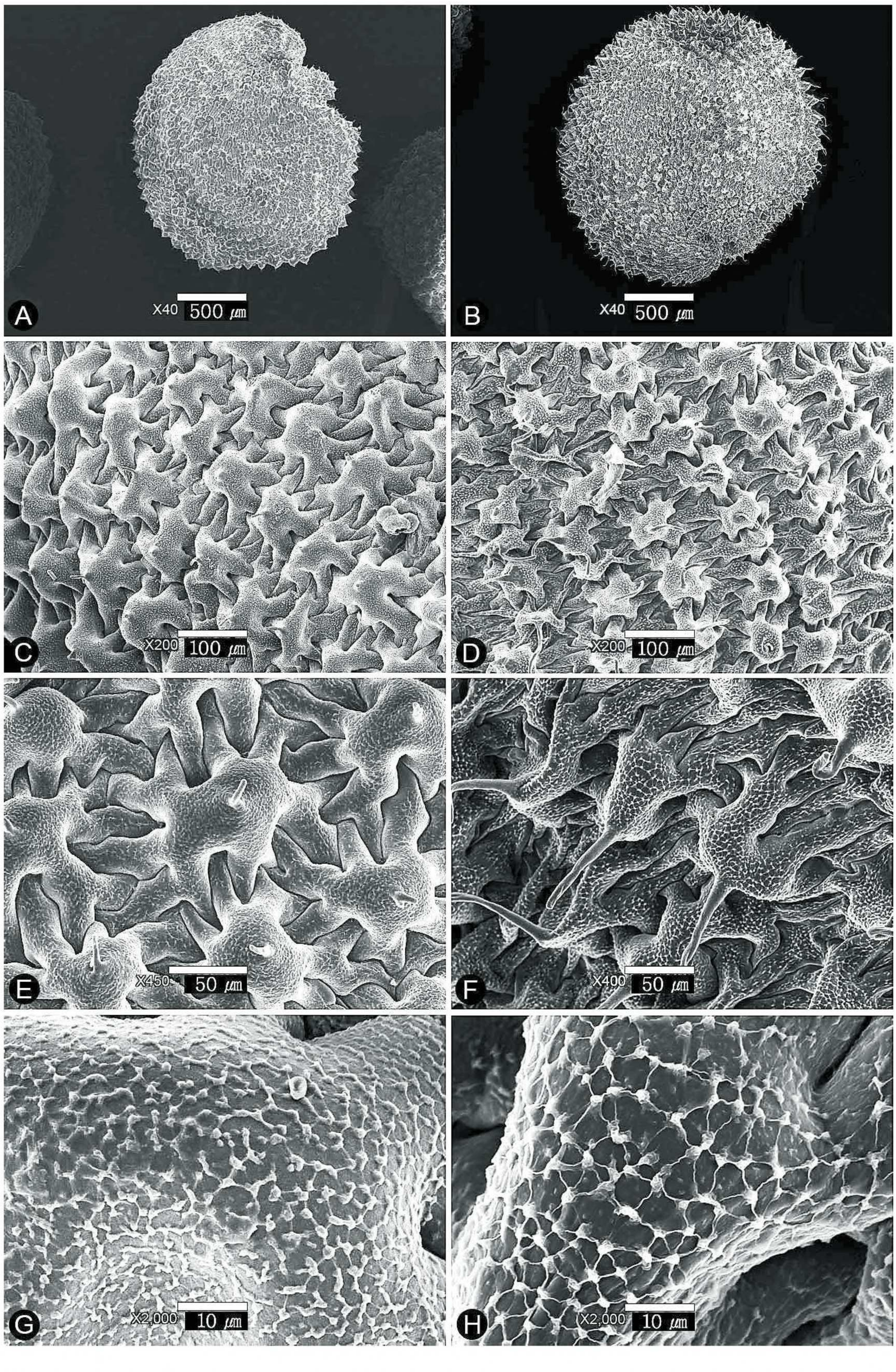

Figure 3. SEM micrographs of seeds of *Pseudostellaria longipedicellata* S. Lee, K. Heo & S. C. Kim (A, C, E, G) and *P. palibiniana* (Takeda) Ohwi (B, D, F, H). —A, B. Fruit shapes. —C–H. Fruit surfaces. Photos A, C, E, and G were taken from *Heo HKI050010* (SKK); photos B, D, F, and H were taken from *S. T. Lee & K. Heo S.Lee050010* (SKK).

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